ADVANCED RF FRONT END TECHNOLOGY. M. I. Herman[1], S. Valas[1] and L. P. B. Katehi.[2], [1]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109 m/s 161-213 martin.i.herman@jpl.nasa.gov, [2]The Radiation Laboratory, Electrical Engineering and Computer Science Department, University of Michigan, Ann Arbor Michigan 48109

Introduction: The ability to achieve low-mass low-cost micro/nano-spacecraft for Deep Space exploration requires extensive miniaturization of all subsystems. The front end of the Telecommunication subsystem is an area in which major mass (factor of 10) and volume (factor of 100) reduction can be achieved via the development of new silicon based micromachined technology and devices. Major components that make up the front end include single-pole double-throw switches, diplexer and solid state power amplifier, Figure 1.

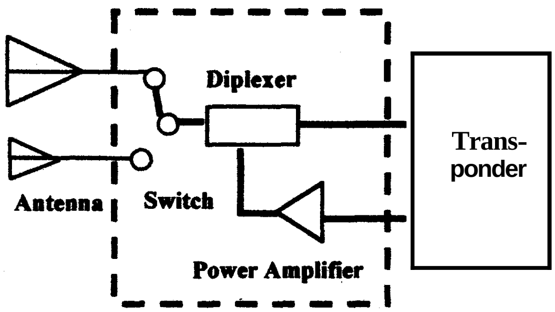

Figure 1. Inside the box outline are the basic front-end components of a Deep Space communication system.

JPL's Center For Space Microsystems - System On A Chip (SOAC) Program has addressed the challenges of front end miniaturization (switches and diplexers). Our objectives were to develop the main components that comprise a communication front end and enable integration in a single module that we refer to as a "cube". In this paper we will provide the latest status of our Microelectromechanical System (MEMS) switches and surface micromachined filter development. Based on the significant progress achieved we can begin to provide guidelines of the proper system insertion for these emerging technologies.

Approach: The baseline approach to our development is silicon technology. The advantages of using silicon are multifaceted Both the semiconductor and the MEMS community have baselined silicon as the dominant technology to develop. The use of silicon as a standard substrate can enable complex subsystem integration via advanced stacking of wafer sections to form complex 3-D components ("cubes"). Compatibility with silicon processing translates to lower manufacturing costs. A final advantage is that this approach is consistent with the other ongoing work in the SOAC program.

RF MEMS Switches: JPL[i] has developed a unique planar RF MEMS design that produces the broadest bandwidth, lowest insertion loss, and highest isolation of any other known single pole double throw (SPDT) switch. Using first order simulations, this design has demonstrated *greater* than 100 dB isolation and less than *0.6* dB insertion loss from DC to 30 GHz. As a benchmark, the best planar SPDT switches to date made using semiconductor devices provide 40 dB isolation and as much as 2.0 dB of loss with one third of the bandwidth capability of the JPL switch design.

The University of Michigan has been leading the development of core MEMS switch elements that can implement a variety of switch architectures.

Diplexers: The University of Michigan has been pioneering the development of X-band micromachined cavity resonators. The proper combination of resonators results in a filter. A diplexer is a combination of 2 filters to allow for a single physical connection to the antenna port and separate paths between the transmit and receive signals. For Deep Space applications an X-band (7.1 - 8.4 GHz) design has been pursued. Our work indicates that this technology more suitable for fulfilling the desired performance goals (high-isolation low-loss) at Ka-band (32 - 35 GHz).

Future Architecture: Based on progress from this task, advanced Si-based front-end components must be located very close to the radiating element and the transceiver/transponder (to reduce transmission-line loss). This is consistent with [redacted] nano-spacecraft concepts. The MEMS switches have wideband operation potential. However, the filter technology seems more applicable to future Ka-band applications.

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[i] NASA New Technology Report (NPO 20663) by Sam Valas, Jet Propulsion Laboratory